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MEETING THE REQUIREMENTS FOR LEASE-VS-BUY ANALYSIS: A CASE STUDY

This paper describes a cost-effectiveness model developed for the National Oceanic and Atmospheric Administration (NOAA) Fleet Replacement and Modernization (FRAM) program, and how the concepts illustrated by the model relate to and meet federal requirements for lease-vs-buy analysis.

The NEM performs lease-vs-buy analysis by calculating a stream of lease payments based on economic and market conditions, and comparing these payments with government acquisition of a ship. The NEM also performs operate-vs-charter analysis. The combination of these analyses and other cost elements results in life cycle cost estimates for various acquisition alternatives, in accordance with OMB Circular A-94.

The NEM compares four acquisition alternatives for NOAA research vessels: (1) government owned, government operated - straightforward government acquisition; (2) contractor owned, government operated - a lease arrangement; (3) contractor owned, contractor operated - a charter arrangement; and (4) government owned, contractor operated - contracting out of services. There are 43 required user inputs arranged in two groups: global factors and cost factors.

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Meeting the Requirements for Lease-vs.-Buy Analysis: A Case Study

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Meeting the Requirements for Lease-vs.-Buy Analysis: A Case Study

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Introduction

With the recently-released OMB Circular A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," the issue of how to perform a useful cost-benefits and/or cost-effectiveness analysis to assist government acquisition is once again on the table in the cost analysis community. Experience has shown that cost analysis is an ever-changing science, and modeling efforts are continuing to keep in step with new requirements and to reflect new practices. This paper discusses a model developed to assist the National Oceanic and Atmospheric Administration (NOAA) with lease-vs.-buy analysis for the Fleet Replacement and Modernization (FRAM) Program. This model incorporates the latest OMB guidance and is flexible enough to meet changing economic and market conditions as well as changes in government and business practice.

Background

Various studies over the past five years have identified NOAA research vessels as some of the oldest ships in the federal fleet. These studies recommended that NOAA either replace or upgrade their fleet. Based on these recommendations, the NOAA Fleet Replacement and Modernization Plan was issued in March 1991 and updated in September 1991. The NOAA FRAM Program Office exists to manage the upgrade of the existing fleet of research vessels.

The NOAA Economic Model (NEM) was developed to support the ship acquisition decision and meet federal requirements for cost analysis. The NEM is the result of extensive primary and secondary research, working closely with the NOAA FRAM Program Manager (PM), and an Independent Verification and Validation (IV&V) by an internationally recognized consulting firm with specific experience in ship acquisition.

In addition to federal requirements for cost analysis, the particular needs of the FRAM office were considered during model development. The ship acquisition decision will be made over time for each ship and is intended to be made objectively and independent of various biases that may exist. The NEM facilitates the acquisition decision by being flexible and independent of bias. Flexibility allows the NEM to meet changing economic, market, and legislative conditions over time, and the ability to process a wide range of input values allows the NEM to be free of mathematical bias. However, the model sacrifices simplicity in order to incorporate these two key characteristics. The 43 variable user inputs are all mathematically linked to the cost output of the model and should be selected carefully by a user who is acquainted with the mathematical algorithms of the model and the ship acquisition process in general.

The NEM is implemented in Excel 4.0 for Windows, and provides the user with a friendly menu-driven software package that accepts input values in pop-up edit windows and worksheets, transforms these inputs into alternative acquisition life cycle cost estimates, and provides a function for viewing and printing various output reports.

In addition to the key requirements of providing flexibility and freedom from bias, the IV&V determined that the NEM meets government and industry requirements for performing a lease-vs.-buy analysis. The following sections discuss these requirements, how the model meets requirements through its mathematical algorithms and logical flow, and how the model may be specifically applied to a given scenario.

Government Requirements

Draft OMB Circular A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," dated 13 July 1992, provides guidance in performing cost decision support analysis. According to the guidance, there are two basic decisions that should be made as a part of the analysis: (1) public investment, and (2) lease-vs.-buy.

The public investment decision applies to analysis of programs that provide benefits and costs to the general public. This decision would be made in determining whether to acquire a ship, not in determining how to acquire the ship. The NEM applies to selecting an acquisition alternative after the decision to acquire has already been made.

The lease-vs.-buy decision is addressed by the NEM. Specific guidelines are offered by OMB Circular A-94 for performing this analysis. The model meets all of these guidelines using standard techniques for cost analysis.

Foremost, the NEM performs a cost analysis by comparing the present value of the life cycle cost of leasing and the present value of the life cycle cost of purchasing the ship using a discount rate and/or inflation rate schedule specified by the user. The system life in years is specified by the user as well. The variable nature of these important economic inputs is recognized, and the model allows for inputs that reflect current economic conditions.

Life cycle costs meet the requirements of the Circular by allowing for the inclusion of the following significant cost elements:

- Research and development costs
- Ship investment costs
    - Ship purchase cost, or
    - Stream of lease payments, including lease extension periods, over the life of the ship
- Additional management costs (i.e. government oversight of lease agreement)
- Operating and support costs over the life of the ship
- Mid-life ship upgrade costs
- Imputed insurance costs
- Additional costs associated with leasing
- Disposal costs associated with purchasing
- Terminal Value associated with purchasing

At this time, no significant tax benefits are allowed by legislation, so none are included in the NEM. However, the model accomodates Investment Tax Credit (ITC) and accelerated depreciation, should tax laws change in the future.

The NEM software allows for sensitivity analysis by including a capability for user input and edit of variables and including a file save function. These capabilities are useful in making multiple runs of the model while varying input values. OMB agrees that performing multiple runs while varying the input values is a reasonable approach to treating uncertainty.

Industry Requirements

Interviews with representatives of government and industry involved in the ship acquisition process identified four acquisition alternatives. The NEM compares these acquisition alternatives for NOAA research vessels:

- Government owned, Government operated (GOGO) - straightforward government acquisition. GOGO life cycle cost is described by the following equation:

$$Investcost_{baseyr} + \sum_{t=1}^{Syslife} (Govt\ OS\ Cost)_{baseyr} + Disposal_{baseyr} - Terminal_{baseyr} \qquad (1)$$

where **Investcost** is the ship investment cost, including research and development costs, if any
Govt OS Cost is the annual government O&S cost
Disposal is the disposal cost of the ship, if any
Terminal is the residual value of the ship at the end of its useful life
baseyr is the economic base year in which life cycle costs are compared
Syslife is the system life of the ship in years within the constraints of the user's inputs to the model
t is generally a year between the first year of acquisition and the last year of system life; in this case t represents years during the ship's service life where O&S costs are realized

- Contractor owned, Government operated (COGO) - a lease arrangement. COGO life cycle cost is described by the following equation:

$$\sum_{t=1}^{Syslife} (Leasepmt_t + Misc\ Mgmt\ Cost_t + Govt\ OS\ Cost)_{baseyr} \qquad (2)$$

where **Leasepmt** is the annualized lease payment
Misc Mgmt Cost is any miscellaneous additional cost that is not included in the calculation of the lease payment (i.e. government oversight of the lease contract)
Govt OS Cost is the annual government ship O&S cost
baseyr is the economic base year in which life cycle costs are compared
Syslife is the system life of the ship in years within the constraints of the user's inputs to the model
t is generally a year between the first year of acquisition and the last year of system life; in this case t represents years during the ship's service life where O&S and lease costs are realized

- Contractor owned, Contractor operated (COCO) - a charter arrangement. COCO life cycle cost is described by the following equation:

$$\sum_{t=1}^{Syslife} (Leasepmt_t + Misc\ Mgmt\ Cost_t + Cont\ OS\ Cost)_{baseyr} \tag{3}$$

where **Leasepmt** is the annualized lease payment
Misc Mgmt Cost is any miscellaneous additional cost that is not included in the calculation of the lease payment (i.e. government oversight of the charter contract)
Cont OS Cost is the annual contracted ship O&S cost
baseyr *is the economic base year in which life cycle costs are compared*
Syslife is the system life of the ship in years within the constraints of the user's inputs to the model
t is generally a year between the first year of acquisition and the last year of system life; in this case **t** represents years during the ship's service life where O&S and lease costs are realized

- Government owned, Contractor operated (GOCO) - contracting out of services. GOCO life cycle cost is described by the following equation:

$$Investcost_{baseyr} + \sum_{t=1}^{Syslife} (Cont\ OS\ Costs)_{baseyr} + Disposal_{baseyr} - Terminal_{baseyr} \tag{4}$$

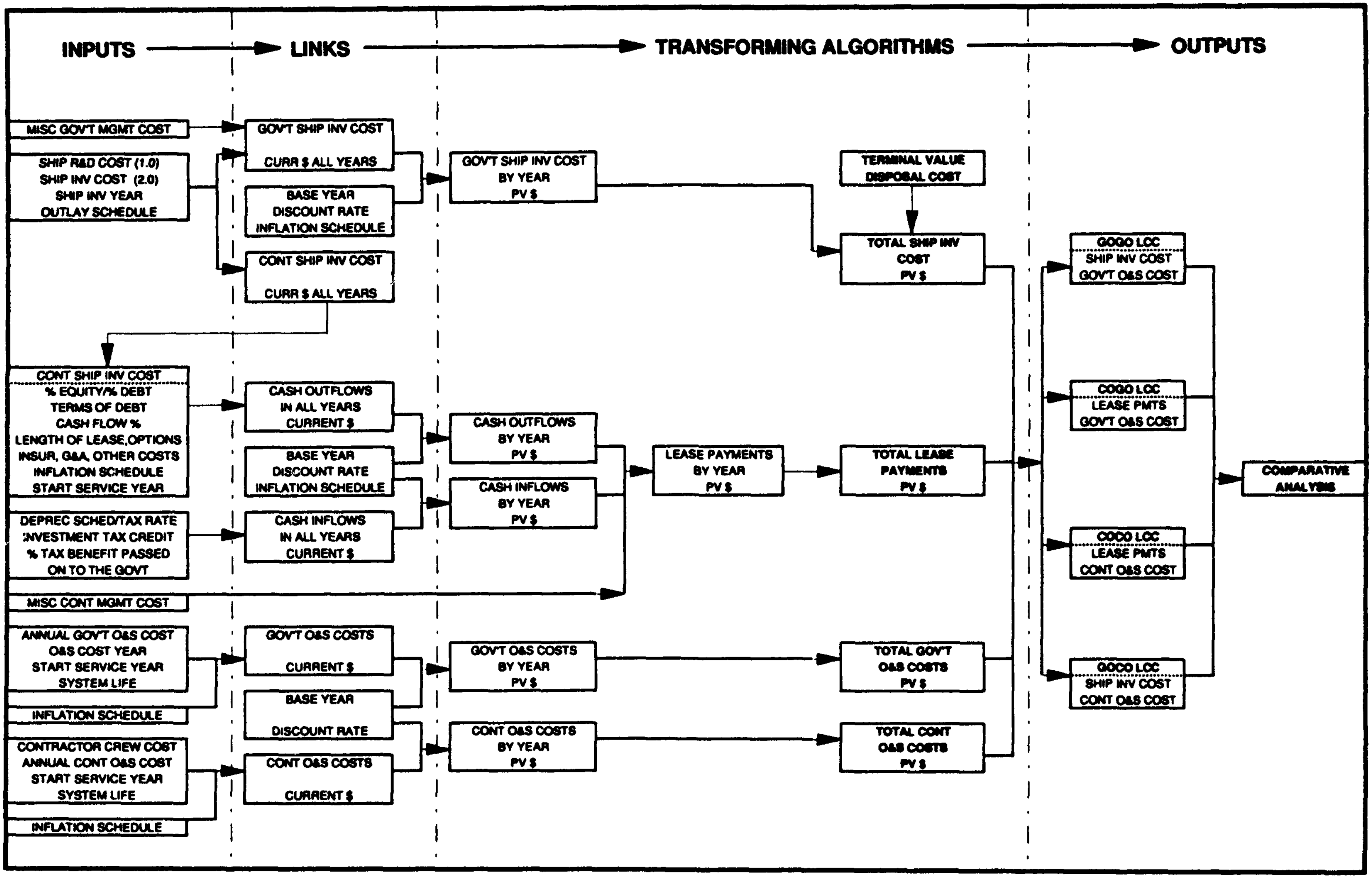
where **Investcost** is the ship investment cost, including research and development costs, if any
Cont OS Cost *is the annual contracted* ship O&S cost
Disposal is the disposal cost of the ship, if any
Terminal is the residual value of the ship at the end of its useful life
baseyr is the economic base year in which life cycle costs are compared
Syslife is the system life of the ship in years within the constraints of the user's inputs to the model
t is generally a year between the first year of acquisition and the last year of system life; in this case **t** represents years during the ship's service life where O&S costs are realized

Model Flow

Figure 1 is a graphical representation of the NEM logical information flow. The inputs are mathematically linked to the transforming algorithms and result in estimated life cycle cost for each of the four acquisition scenarios. Then, a comparison is made between the alternatives. The model consists of seven major components:

1. Government ship investment costs, including R&D costs, if any
2. Contractor ship investment costs
3. Ship lease costs
4. Government operating and support costs
5. Contractor operating and support costs
6. Terminal value and disposal costs
7. Net present value comparison of alternative scenarios

Figure 1. NOAA Economic Model Information Flow



Government and contractor ship investment costs

The first two components of the NEM are basic conversions from current dollars entered in a cost element structure to present value dollars for the year of economic comparison. The cost element structure for the input of ship investment costs is shown in Table 1.

Table 1. Ship Investment Cost Element Structure

0.0	System Total
1.0	Research and Development
2.0	Investment
...2.1	...Ship Acquisition
...2.2	...Lease Payments
...2.3	...Project Management
......2.3.1	.......Systems Management
......2.3.2	.......Personnel
......2.3.3	.......Materials
......2.3.4	.......Contractor Support
.........2.3.4.1	..........PMA
.........2.3.4.2	..........SETA
.........2.3.4.3	..........Other
...2.4	...Systems Engineering
...2.5	...Data

Table 1 contains the cost elements found in the actual input spreadsheet for NEM government and/or contractor ship investment costs. The purpose of the cost element structure is to provide an indentured list of significant cost elements that should be considered in the analysis. Note that the model will accept numbers at lower levels of indenture and sum these to the next highest level, or accept numbers at higher levels of indenture and override the summing function.

The next step in calculating ship investment costs is to allocate the total cost to the years in which expenditures will be made. Table 2 shows the case study outlay schedules for government and contractor, by month. The outlay schedule may be changed by the user to model different scenarios.

Table 2. Outlay Schedules
Payments as a Monthly Percentage of Total Acquisition Cost

Month	Govt Pmt	Cont Pmt	Month	Govt Pmt	Cont Pmt
1	0.0%	25%	19	3.7%	
2	0.3%		20	3.9%	
3	0.8%		21	4.0%	
4	1.2%		22	4.1%	
5	1.7%		23	4.2%	
6	2.1%		24	4.2%	25%
7	2.2%		25	4.4%	
8	2.4%		26	4.2%	
9	2.5%		27	4.1%	
10	2.5%		28	4.0%	
11	2.5%		29	3.8%	
12	2.5%	25%	30	3.7%	
13	2.5%		31	3.5%	
14	2.6%		32	3.5%	
15	2.8%		33	2.4%	
16	3.0%		34	2.2%	
17	3.2%		35	1.2%	
18	3.4%		36	0.7%	25%

The model sums the monthly outlay schedule to provide annual percentage outlays and allocates the investment cost to outlay years. No inflation is applied within a year, because the ship investment cost as shown in the cost element structure is assumed to reflect a negotiated contract that already includes the effects of inflation. Annual ship investment costs are simply:

$$Ship\ Inv\ Cost_t = Total\ Ship\ Inv\ Cost_{start\ acq\ year} \times Outlay\ \%_t \qquad (5)$$

where **TOTAL SHIP INV COST**$_{start\ acq\ year}$ is the ship investment cost, as input to the cost element structure

OUTLAY % is the percentage of total costs paid in the current year **t**

t is generally a year between the first year of acquisition and the last year of system life; in this case **t** represents the years of acquisition expenditure outlays

The final step in calculating ship investment cost for the government or the contractor is to convert current dollars to present value. If the economic base year specified by the user for purposes of comparison is greater than the year in which ship investment dollars are presented, an inflation factor is used to arrive at present value:

$$\textit{Total Ship Inv Cost}_{\textit{base year}} = \sum_{t=1}^{\textit{Outlay}} \textit{Ship Inv Cost}_t \times (1+\textit{infl})^{\textit{base year}-t} \tag{6}$$

where **SHIP INV COST$_t$** is the ship acquisition outlay allocation for year t as calculated in Equation 5
OUTLAY is the number of outlay years
INFL is the user-specified inflation factor for the year in which the outlay occurs
t is generally a year between the first year of acquisition and the last year of system life; in this case **t** represents the years of acquisition expenditure outlay

If the economic base year specified by the user is less than the year in which ship investment dollars are presented, the discount rate is used to arrive at present value:

$$\textit{Total Ship Inv Cost}_{\textit{base year}} = \sum_{t=1}^{\textit{Outlay}} \textit{Ship Inv Cost}_t \times \frac{1}{(1+\textit{disc})^{t-\textit{base year}}} \tag{7}$$

where **SHIP INV COST$_t$** is the ship acquisition outlay allocation for year t as calculated in Equation 5
OUTLAY is the number of outlay years
DISC is the user-specified discount rate
t is generally a year between the first year of acquisition and the last year of system life; in this case **t** represents the years of acquisition expenditure outlays

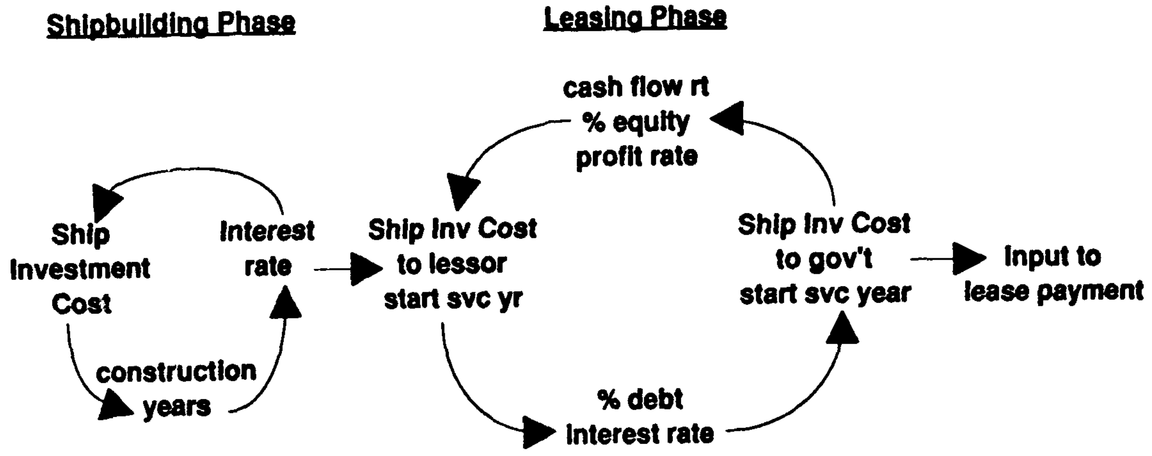
Ship lease costs

Calculating the ship lease cost is perhaps the most complex component of the model. The computations in NEM reflect current business practices.

There are two integrated phases of a build-to-lease acquisition alternative. First the ship is constructed by a shipbuilder and financed with the shipbuilder's line of credit. As costs are incurred, the shipbuilder uses the line of credit. Interest accrues, but no debt service payments are made during ship construction. When ship construction is completed, the ship is purchased by the lessor, using a combination of equity investment and debt to acquire the ship. This contractor owns the ship and leases it to the government for a specified period of time. Lease costs are a function of: ship investment costs to the contractor; the required rate of return on the contractor's equity to account for inflation, risk, and profit; and other cash outflows from the contractor. Figure 2 is a graphic representation of the logical flow of the lease algorithms.

In the shipbuilding phase, ship investment cost is transformed into a greater ship investment cost that includes interest accrued during construction. In the leasing phase, ship investment cost is once again transformed into a ship investment cost that reflects debt service payments and profit.

Figure 2. Logical Flow of Ship Lease Financing



Equity investment is a function of the user-specified equity percent applied to the contractor's ship investment cost. This equity investment is then transformed by the NEM into present value dollars as of the beginning of the lease period using the discount rate as applied in Equation 7. Then, equity service payments are calculated using a standard annuity payment formula:

$$Total\ Equity\ Svc\ Pmt = \frac{Equity_{start\ lease\ year}}{\left[\frac{1 - \frac{1}{(1+ror)^{lease\ years}}}{ror}\right]} \qquad (8)$$

where **EQUITY**$_{start\ lease\ year}$ is the total equity investment in present value dollars as of the first year of the lease
ROR is the profit rate or rate of return on the equity investment
LEASE YEARS is the number of years of the lease

The result is a stream of equal payments over the term of the lease in current dollars which may be converted to present value in terms of the user-specified economic base year.

The NEM accounts for the lessor's deferring profit until later years in order to make the lease arrangement more attractive to the government. The total equity service payment may be adjusted by a user-specified cash flow rate to pass lower equity service payments on to the government in the first lease period. The balance of equity and profit that is unpaid continues to accrue interest at the profit rate and the new balance is used to calculate new equity service payments in the same way as shown in Equation 8 in the next lease period.

Debt service payments are calculated in a *similar manner* as equity service payments, except that there is no option for payments to be deferred to future lease option periods. This is because a bank will not be likely to finance a ship construction that is not secured with lease payments high enough to begin paying back the loan immediately as it comes due.

The total debt is a function of the user-specified debt percent applied to the contractor's ship investment cost. The debt service payments are calculated using a standard annuity payment formula:

$$Debt\ Svc\ Pmt = \frac{Debt_{start\ svc\ year}}{\left[\frac{1 - \frac{1}{(1+intr)^{loan\ years}}}{intr}\right]} \qquad (9)$$

where **DEBT**$_{start\ lease\ year}$ is the total debt in present value dollars as of the first year of the lease
INTR is the long term interest rate
LOAN YEARS is the number of years of the loan

The result is a stream of equal payments over the term of the lease in current dollars which may be converted to present value as of the user-specified economic base year.

Insurance costs to the lessor are calculated in the NEM and passed through to the government in the lease payments. Insurance increases as a result of inflation, but also decreases as the ship's value decreases. Each year's payment is calculated using the following equation:

$$Insurance_t = \prod_{t=1}^{SYSLIFE} Insurance\ \% \times RV_t \times (1 + Infl)^t \tag{10}$$

where **INSURANCE** is the insurance payment
INSURANCE % is the user-specified insurance cost expressed as a percent of residual value
RV$_t$ is the residual value of the ship at time **t** using straight-line economic depreciation
SYSLIFE is the system life of the ship in years within the constraints of the user's inputs to the model
INFL is the inflation factor in each year as input by the user
t is generally a year between the first year of acquisition and the last year of system life; in this case **t** represents years during the ship's service years where insurance costs are realized

At a user-specified time in the life cycle of the ship, the insurance will remain a percent of the same residual value from that time forward to the end of the life cycle. The result of the computation shown in Equation 10 is a stream of current dollar insurance costs over the duration of the lease. These may be converted to present value terms as illustrated previously.

Contractor General and Administrative (G&A) and overhead expenses are input as a percent of total annual costs of the lease:

$$GA/OH\ Cost_t = GA/OH\ \% \times (Equity\ Svc + Debt\ Svc + Insurance)_t \tag{11}$$

where **GA/OH %** is the user-specified overhead cost as a function of all other costs
EQUITY SVC is the equity service payment for the current year
DEBT SVC is the debt service payment for the current year
INSURANCE is the insurance cost for the current payment
t is generally a year between the first year of acquisition and the last year of system life; in this case **t** represents the years of service during the lease period

Finally, the total lease payment is calculated by summing up the present value of the costs discussed in this section. It is assumed that in real life, the contractor calculates the lease payment as a function of all applicable costs as of the year in which the lease begins. Therefore, total lease cost is adjusted to present value at the first year of the lease. Then, the lease payment is calculated using the annuity formula described previously:

$$Lease\ Pmt_t = \frac{Total\ Lease\ Cost_{start\ lease\ year}}{\left[\frac{1 - \frac{1}{(1+disc)^{lease\ years}}}{disc}\right]} \qquad (12)$$

where **TOTAL LEASE COST**$_{start\ lease\ year}$ is the sum of the equity service payment, debt service payment, insurance, and G&A/overhead in present value as of the beginning of the lease period.

DISC is the user-specified discount rate

LEASE YEARS is the number of years in the lease

The result is a stream of lease payments over the length of the lease in current dollars, that may be converted to present value using the discount rate. Total lease cost is the sum of all lease payments in present value dollars over the ship's life cycle, to include the primary lease period and all lease extensions.

In addition to the lease payment, there may be some miscellaneous management costs associated with leasing the ship, such as government oversight of the lease. These are added to the lease payment in the year in which they are realized.

Government and Contractor O&S costs

Government and Contractor operating and support costs are entered into a cost element structure as shown in Table 3.

Table 3 contains the cost elements found in the actual input spreadsheet for NEM government and contractor O&S costs. As discussed previously, the model will accept numbers at lower levels of indenture and sum these to the next highest level, or accept numbers at higher levels of indenture and override the summing function. The NEM allows input for both government and contractor O&S costs at the cost element structure level, and there is an additional input worksheet for computing contractor crew costs using categories of crew type, quantity of each crew type on the ship, and the labor cost for each crew type.

Table 3. Ship Operating and Support Cost Element Structure

3.0	Annual Operating and Support
...3.1	...Shore Support
......3.1.1	......Management
......3.1.2	......Scheduling
......3.1.3	......Contractor Support
...3.2	...Fleet Management
......3.2.1	......Systems Management
......3.2.2	......Personnel
......3.2.3	......Materials
......3.2.4	......Contractor Support
...3.3	...Ship Crew
...3.4	...Ship Consumables
......3.4.1	......Petroleum
......3.4.2	......Lubricants
......3.4.3	......Repair Parts
......3.4.4	......Supplies
......3.4.5	......Subsistence
...3.5	...Maintenance
......3.5.1	......Intermediate
.........3.5.1.1	.........Overhead
.........3.5.1.2	.........Direct Labor
.........3.5.1.3	.........Material
......3.5.2	......Overhaul
..........3.5.2.1	.........Overhead
..........3.5.2.2	.........Direct Labor
..........3.5.2.3	.........Material
...3.6	...Repair of Repairables
...3.7	...Replenishment Spares
...3.8	...Engineering Support
...3.9	...Port Services

The model automatically inflates O&S costs over the life of the ship as discussed previously. Operating and support costs are calculated as follows:

$$OS\ Cost_t = OS\ cost_{OS\ year} \times \prod_{t=1}^{SYSLIFE} (1 + infl)^{t - OS\ year} \quad (13)$$

where **OS Cost** is the annual O&S cost
OS year is the year in which annual O&S costs are input
SYSLIFE is the system life of the ship in years within the constraints of the user's inputs to the model
Infl is the inflation factor in each year
t is generally a year between the first year of acquisition and the last year of system life; in this case **t** represents years during the ship's service years where O&S costs are realized

The result is a stream of annual O&S costs in current dollars that may be converted to present value in terms of the economic base year and then summed.

Terminal value and disposal costs

The NEM allows for a user-specified percent factor to be applied to intial ship acquisition costs to estimate any residual value of the ship at the end of its useful life. Disposal costs and the year in which these costs are presented are user inputs. Both terminal value and disposal costs are converted into present value dollars using the discount rate.

NPV comparison of alternatives

The life cycle cost of each of the acquisition alternatives is a combination of the computations presented in the previous sections of this paper.

For the first acquisition alternative, government-owned; government-operated, the present value of LCC is reflected by the following equation:

$$\textit{GOGO LCC} = \textit{Total Govt Ship Inv Cost}_{base\ year} + \textit{Govt OS Cost}_{base\ year} + \textit{Disposal}_{base\ year} - \textit{Residual}_{base\ year} \tag{14}$$

where **GOGO LCC** is the total life cycle cost as defined within the constraints of the model of the government owned, government operated acquisition alternative
TOTAL GOVT SHIP INV COST is the total ship acquisition cost in base year dollars
GOVT OS COST is the total government operating and support cost in base year dollars
DISPOSAL is the disposal cost in base year dollars
RESIDUAL is the residual value of the ship at the end of its useful life in base year dollars

In the case of the leased ship, the present value of Life Cycle Costs is reflected by the following equation:

$$\textit{COGO LCC} = \textit{Total Lease Cost}_{base\ year} + \textit{Govt OS Cost}_{base\ year} \tag{15}$$

where **COGO LCC** is the total life cycle cost as defined within the constraints of the model of the contractor owned, government operated acquisition alternative
TOTAL LEASE COST is the total lease cost in base year dollars
GOVT OS COST *is the total government operating and support cost in* base year dollars

The time-charter alternative has a LCC that is reflected by the following equation:

$$\textit{COCO LCC} = \textit{Total Lease Cost}_{base\ year} + \textit{Cont OS Cost}_{base\ year} \tag{16}$$

where **COCO LCC** is the total life cycle cost as defined within the constraints of the model of the contractor owned, contractor operated acquisition alternative
TOTAL LEASE COST is the total cost to lease the ship
CONT OS COST is the total contractor operating and support cost

Finally, the contracted service alternative, government owned and contractor operated, has a LCC that is reflected by the following equation:

$$\textit{GOCO LCC} = \textit{Total Govt Ship Inv Cost}_{base\ year} + \textit{Cont OS Cost}_{base\ year} + \textit{Disposal}_{base\ year} - \textit{Residual}_{base\ year} \tag{17}$$

where **GOCO LCC** is the total life cycle cost as defined within the constraints of the model of the government owned, contractor operated acquisition alternative

The comparison of the results of Equations 14 through 17 will provide a ranking of the four acquisition alternatives in terms of life cycle cost.

Case Study

The case study described in this paper describes a fictional research vessel. Economic variables are those that would be used in a real case and business practice variable inputs are the result of extensive research in the ship building and leasing industry. Table 4 is an actual output of the NEM and contains a summary of the input data used in the test case.

Table 5 is an actual output of the NEM and contains a summary of the comparison of the alternatives. The cost elements are shown at the second level of indenture, and identified by their number in the cost element structure. There are three sections in the summary comparison: current dollar, constant dollar, and present value dollar comparisons. The "Delta" column shows the difference between the acquisition alternatives and the status quo: a government owned, government operated ship. The purpose of the "Delta" column is to show the increase or decrease in costs if an acquisition method other than the status quo is selected.

The test case included sensitivity analysis. Twenty-five test runs were performed using high and low values for each input. Although there is a direct relationship between some input values, such as inflation rate, discount rate, long term interest rate, and rate of return (profit), each input variable was taken in turn in order to isolate the impact of each variable on the total life cycle cost. Certain input variables have significant effect on the outcome of the model. These are:

- ship acquisition costs
- discount rate
- annual inflation rate
- ship O&S costs, including crew costs
- long term interest rate

The model responded logically to the sensitivity analysis. For example, as the discount rate increases, the model output will decrease. As inflation rates rise, the model output will also rise. The sum of the impacts of these opposing input variables will depend on the changes in the discount and inflation rates provided by OMB in the coming years.

Small increases in annual O&S costs result in great increases in life cycle costs. This makes sense, as the small increase is realized every year over the life of the system.

Table 4. Inputs to Case Study

Ship Characteristics			
Ship Name	Generic Ship		
Run Description	Demonstration		
Endurance	High		
Displacement	3400 t		
Length	350'		
Propulsion	0		
Global Variables			
Economic Variables		Time Variables	
Discount Rates	7.69%	Base Year	1995
LT Interest Rate	6.10%	System Life	30
Federal Tax Rate	34.00%	ACRS Schedule	SLN
State Tax Rate	6.00%	Start Acq/Construction Year	1995
		Start Service Year	1998
		Mid-Life Upgrade Year	2012
Cost Inputs			
Investment Costs		O&S Costs	
Govt Ship Acq Cost	$40,000	Govt O&S Costs	$2,359
Govt Project Mgmt Cost	$5,000	Cont O&S Costs	$2,346
Cont Ship Acq Cost	$40,000	Govt Crew Costs	$1,074
Cont Project Mgmt Cost	$3,000	Cont Crew Costs	$1,061
Yr in which costs presented	1995	Yr in which costs presented	1995
Lease Inputs		Mid-Life Upgrade	
% Debt	80%	Duration of Upgrade	1
% Equity	20%	Upgrade Cost	$23,000
Return on Equity	13%	Yr in which costs presented	1995
Length of Lease	7	Terminal/Disposal Value	
Length of Debt Instrument	7	Terminal Value (%)	10%
ITC	0%	Disposal Cost	$0
% ITC qualified	0%	Yr in which costs presented	1995
% tax benefits passed on	0%		
Ann. Insurance costs (%)	0%		
% residual value where insurance becomes stable	50%		
Ann. G&A/OH costs (%)	5%		
Yr in which costs presented	1995		

Table 5. Summary Comparison of Case Study

NOAA ECONOMIC MODEL SHIP: Generic Ship Life Cycle Costs (in thousands) Summary Demonstration						
	Current (Then Year) Dollars		Constant 1995 Dollars		PV 1995 Dollars	
	Total	Delta	Total	Delta	Total	Delta
GOGO						
1.0	$0	$0	$0	$0	$0	$0
2.0	$78,329	$0	$66,841	$0	$50,786	$0
3.0	$104,333	$0	$68,400	$0	$31,044	$0
4.0	$0	$0	$0	$0	$0	$0
5.0	$0	$0	$0	$0	$0	$0
6.0	($4,500)	$0	($2,241)	$0	($420)	$0
Total	$178,161	$0	$133,000	$0	$81,410	$0
COGO						
1.0	$0	$0	$0	$0	$0	$0
2.0	$133,029	$54,701	$100,181	$33,340	$56,343	$5,557
3.0	$104,333	$0	$68,400	$0	$31,044	$0
4.0	$0	$0	$0	$0	$0	$0
5.0	$0	$0	$0	$0	$0	$0
6.0	$0	$4,500	$0	$2,241	$0	$420
Total	$237,362	$59,201	$168,581	$35,581	$87,387	$5,977
COCO						
1.0	$0	$0	$0	$0	$0	$0
2.0	$133,029	$54,701	$100,181	$33,340	$56,343	$5,557
3.0	$101,551	($2,782)	$68,041	($359)	$30,217	($828)
4.0	$0	$0	$0	$0	$0	$0
5.0	$0	$0	$0	$0	$0	$0
6.0	$0	$4,500	$0	$2,241	$0	$420
Total	$234,580	$56,419	$168,222	$35,221	$86,559	$5,150
GOCO						
1.0	$0	$0	$0	$0	$0	$0
2.0	$78,329	$0	$66,841	$0	$50,786	$0
3.0	$101,551	($2,782)	$68,041	($359)	$30,217	($828)
4.0	$0	$0	$0	$0	$0	$0
5.0	$0	$0	$0	$0	$0	$0
6.0	($4,500)	$0	($2,241)	$0	($420)	$0
Total	$175,379	($2,782)	$132,641	($359)	$80,582	($828)

Summary and Conclusions

The NOAA Economic Model (NEM) is the result of an extensive search for an existing model that would assist in the lease-vs.-buy, operate-vs.-charter acquisition decisions that face NOAA. While finding several cost analysis models, each had serious shortcomings with respect to the FRAM decision. Much of the reason for this is the ever-changing science of cost analysis itself. However, each existing model was useful in the development of the NEM. The NEM is a combination of existing cost estimating structures, current economic analysis techniques, expert opinions, and the experience of the model development team.

Several Government and industry organizations were consulted regarding their experience with ship acquisition. The inputs to the test case provided a reasonable scenario for a ship acquisition, and were transformed by the model, as expected, into cost outputs that can aid in decision-making. As proven in the sensitivity analyses performed and the IV&V, the model adequately assists the lease-vs.-buy, operate-vs.-charter acquisition decisions when provided with realistic data.

In its current form, the NEM may be used to assist in FRAM ship acquisition decisions. It meets government and industry requirements, and it calculates accurately. The practicality of the results depend on the user. The user should be thoroughly familiar with the model in order to ensure that logical input data is used. The complexity of the model will always require a user who is experienced in cost analysis and the ship acquisition process specifically.